Dynamic Database (DDB)

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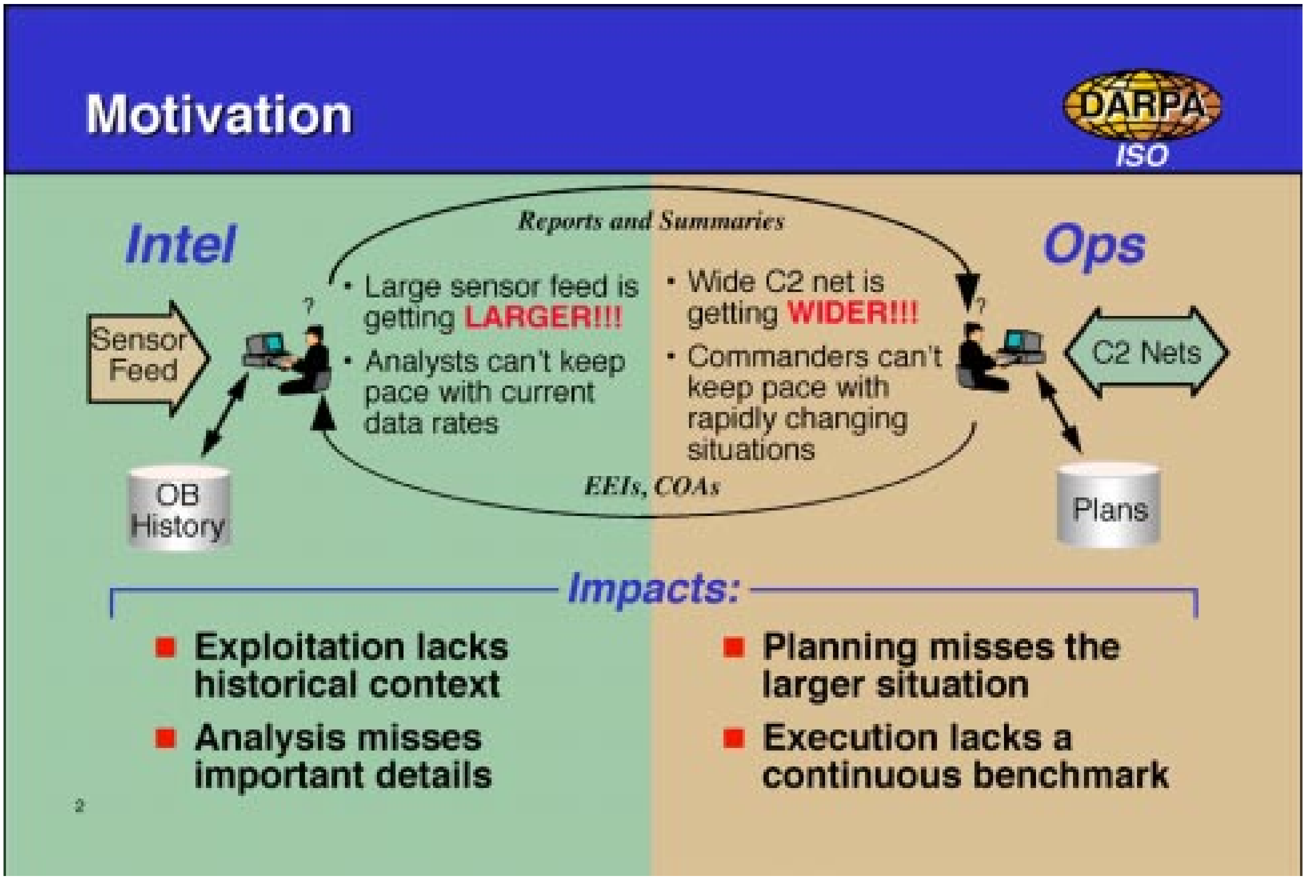
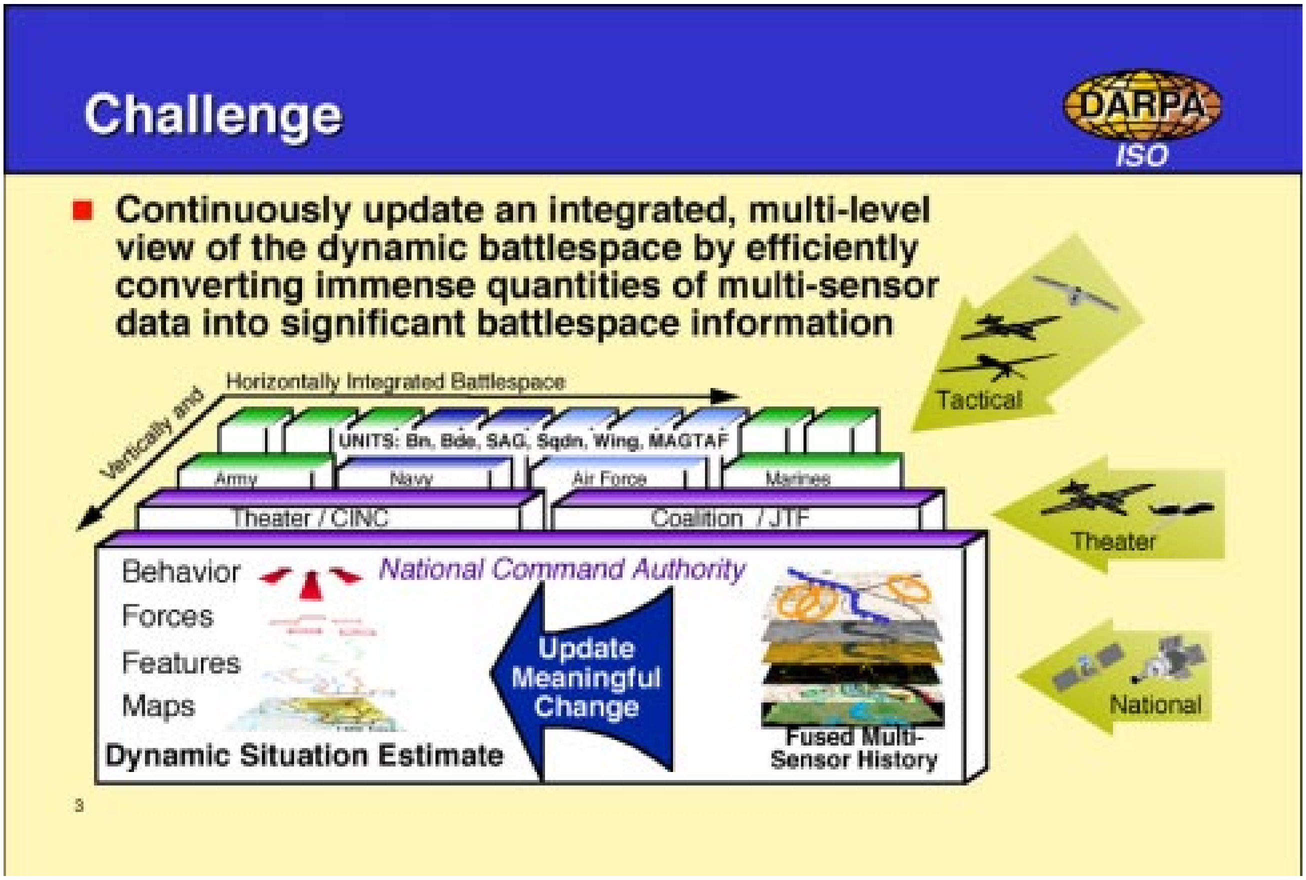


As the number of sensors, platforms, exploitation sites, and command and control nodes continues to grow, analysts and commanders increasingly require the ability to rapidly sift through large volumes of wide-area sensor data to assess both friendly and enemy situations. Complicating this scenario is the fact that current military situation awareness systems exploit only a fraction of all available multisensor data, and are unable to maintain a spatio-temporal history of the battlespace suitable for detecting tactically significant patterns and events. Additionally, today's situation estimates are produced by disjoint, labor-intensive systems that react slowly and asynchronously to rapidly changing terrain, environment, and operational conditions.

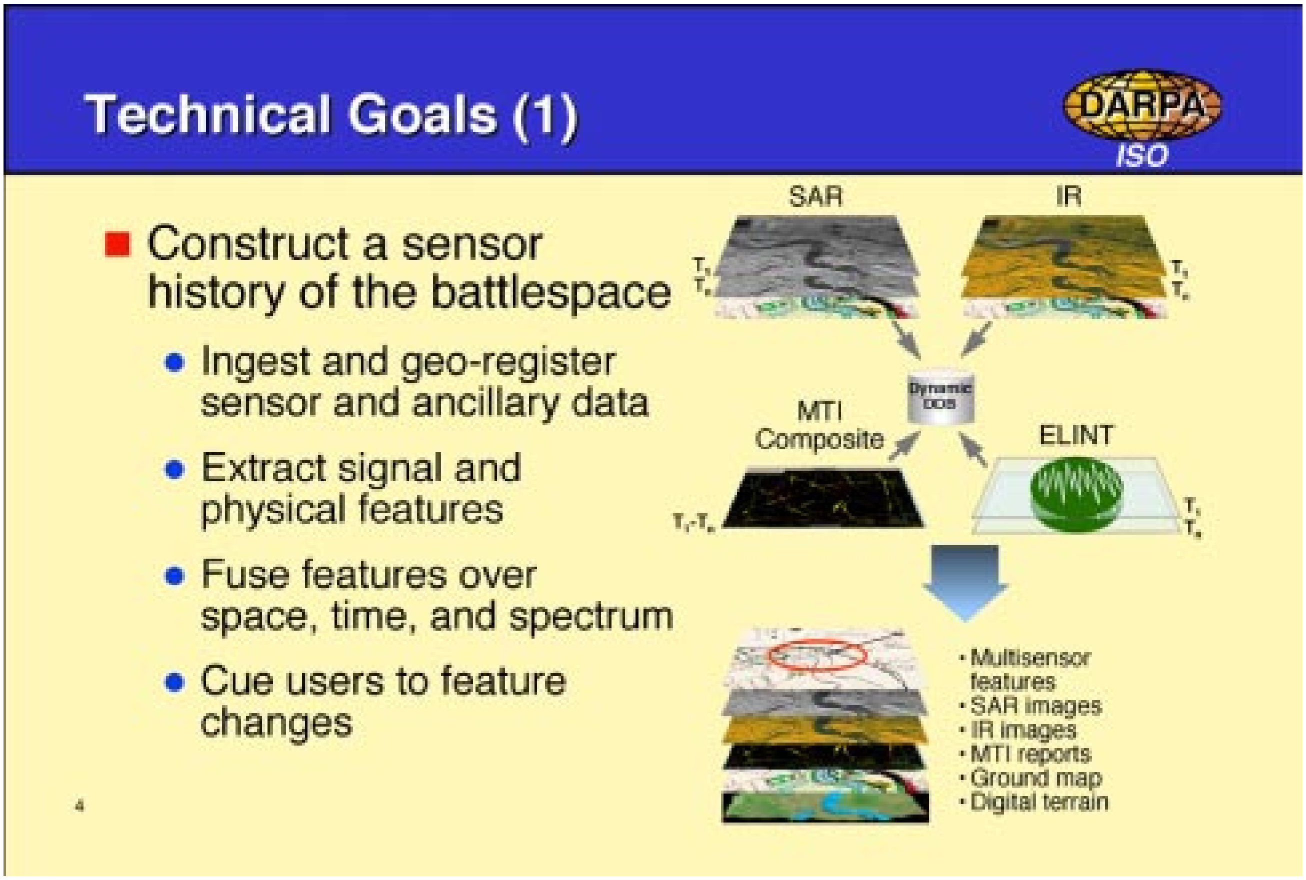
These problems significantly impact our ability to rapidly produce and act on comprehensive situation intelligence. Image analysts lack historical context with which to identify battlespace trends and infer enemy intent. All source analysts overlook valuable cross-sensor clues that indicate tactically significant change. Distributed planners do not have ready access to consistent situation information and therefore may produce conflicting plans. Commanders lack a continuously updated benchmark of the battlespace with which to monitor and assess enemy and own operations.



The overarching goal of the Dynamic Database (DDB) program is to <u>efficiently</u> produce and continuously update a situation estimate of the dynamic battlespace using all available sensor data. The right hand side of the slide provides examples of the sensors we plan to exploit. They include both manned and unmanned SIGINT and IMINT collection assets controlled at multiple levels of the command echelon.

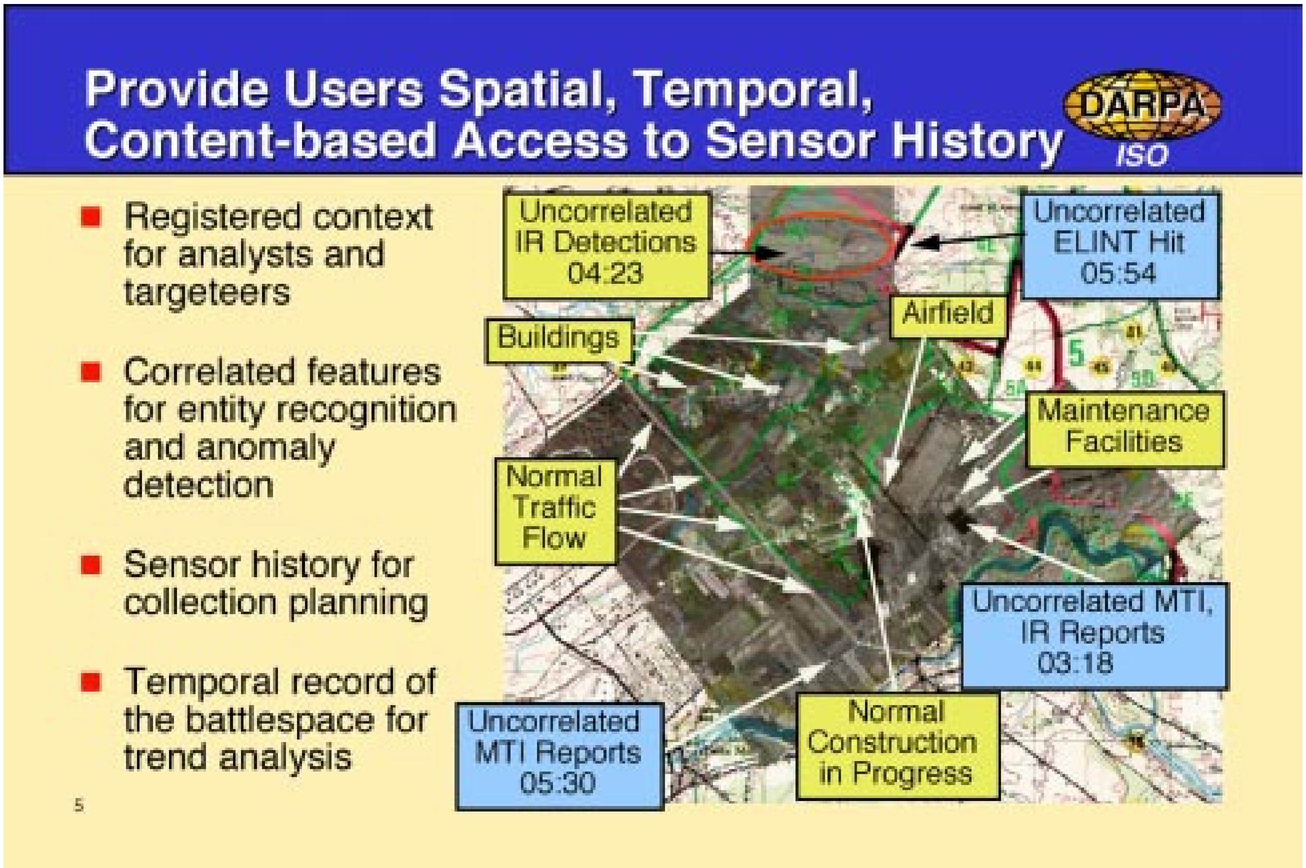
The word "efficient" has two important connotations. First, a large portion of today's sensor data winds up on the cutting room floor because there aren't enough analysts with enough time to review it all. Our goal is to develop signal processing techniques that extract salient information from all multi-sensor data, track and recursively update this information over time, and store it in an efficient, readily accessible manner. Second, we will develop highly advanced multi-sensor fusion techniques that allow us to translate significant battlespace changes into sensor observables that can be detected as early as possible in the processing chain. By doing so, we avoid the need to spend expensive computational resources converting all signal data to actionable intelligence information, and we focus the analyst's attention only on tactically significant events.

Finally, we recognize that tomorrow's Commanders will be highly networked in a distributed, information-intensive environment. We will therefore develop technologies that allow warfighters to continuously share and synchronize local situation changes across service, discipline, and echelon boundaries.



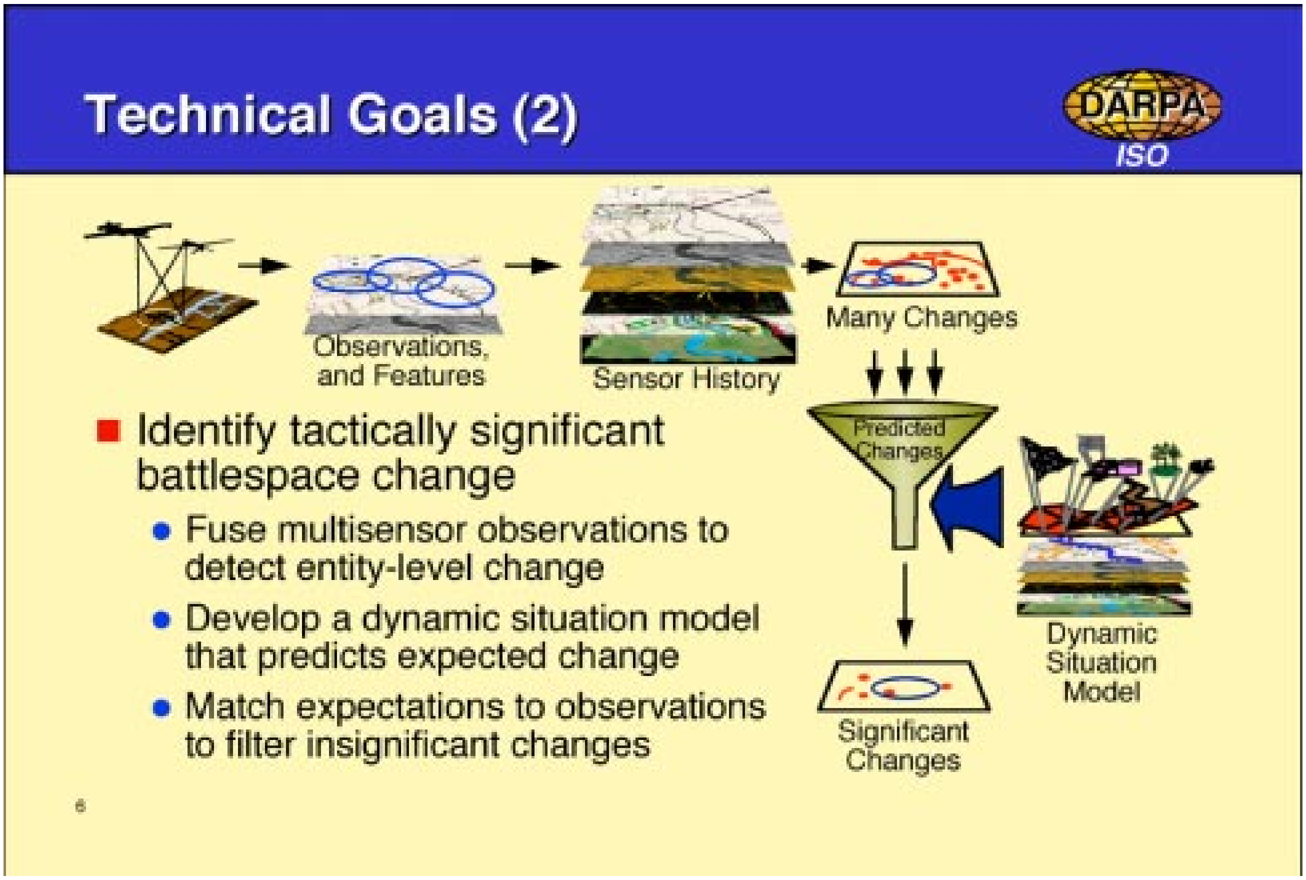
The objective of goal (1) is to construct and provide DDB users rapid access to a complete sensor history of the battlespace. Sensor observations, which include signals, waveforms, images, and derived information such as object attribute features, will be geo-registered and stored over time. Meaningful feature statistics will be selected and recursively updated with each new sensor observation as a means of efficiently characterizing normal battlespace conditions over time. When practical, object features and their corresponding spatial and temporal statistical characterizations will be stored in the sensor history in lieu of memory-intensive raw signals, waveforms, and images.

Advanced database technologies and services will also be developed to manage massive quantities of heterogeneous, time-sensitive sensor data. Data query services are required that support inexact queries of spatial and temporal information. Update services will be developed that rapidly fuse new sensor observations with historical database contents, and remove or augment outdated contents. Reporting services will automatically notify users and client application of significant database changes in response to pre-defined user needs profiles. Product pedigrees will characterize all operations performed on a database product. Computation services will rapidly incorporate and update new and modified applications used to construct and exploit the DDB sensor history.



The DDB sensor history will be used for many different purposes. It will provide readily accessible spatial and temporal context for image and signal exploitation, correlated single and multiple intelligence information for all-source fusion, a complete history of the observed battlespace for collection planning, accurately geo-positioned signals and images for precision targeting and battle-damage assessment, and sensor-derived battlespace features needed to support mission planning and rehearsal.

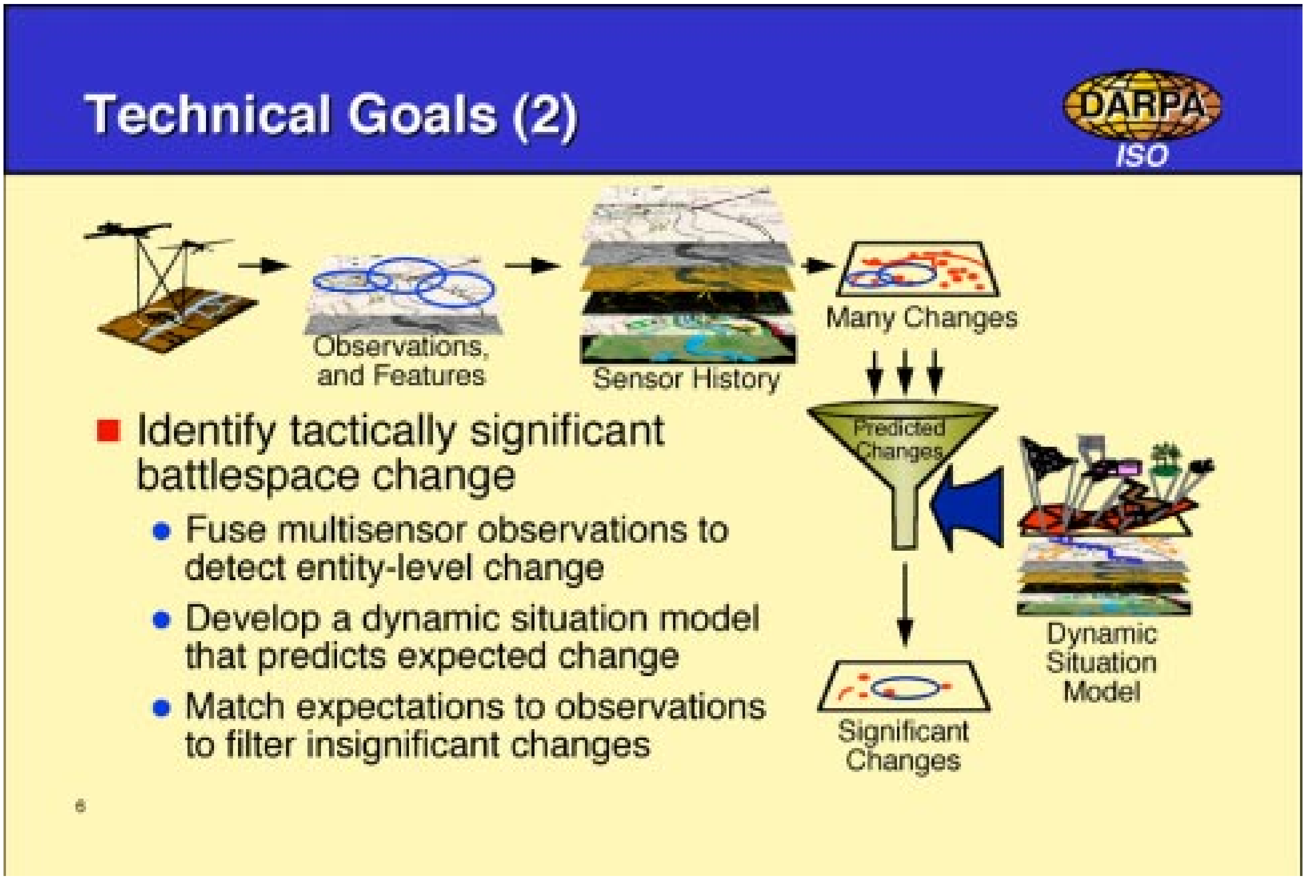
In this example, signals, images, and MTI reports are mosaiced and overlayed on a 1:50,000 map. Users will possess the ability to rapidly query and view spatial, temporal, and spectral data through advanced human computer interfaces. Normal changes, such as routine MTI reports and diurnal IR fluctuations are automatically recorded in the database, while uncorrelated changes are flagged for further processing. Unlike today's exploitation systems that provide "soda straw," single sensor views of a static battlespace, the DDB will provide large regions of registered multisensor data that capture the dynamics of a changing battlespace.



The objective of goal (2) is to mitigate the steadily growing burden placed on signal and image analysts by the emergence of new and highly capable battlespace sensors. Revolutionary multisensor fusion algorithms will be developed that effectively reduce massive sensor data quantities by identifying and focusing the analyst's attention on tactically significant events.

Alternative multisensor fusion architectures will be investigated that vary from relatively straightforward approaches that fuse the outputs of single sensor algorithms, to more complex approaches that fuse multisensor signals, images, and features early in the change detection process. Initial development activities will focus on the use of X-band SAR, IR, MTI, and ELINT sensors in broad area search scenarios. Additional sensors and operational scenarios will be incrementally phased in over time.

Approaches for detecting significant events will include both data-driven and model-driven algorithms. Data-driven algorithms will employ advanced spatio-temporal processing techniques that exploit multisensor data and features stored in the sensor history database. A Dynamic Situation Model and supporting algorithms will be developed that mitigate the detection of false changes by predicting and accounting for expected phenomena. The Dynamic Situation model will provide an integrated, layered representation of the battlespace. Situation layers will include geo-spatial data, environmental conditions, raw sensor data (when appropriate), derived features, entities, and forces.



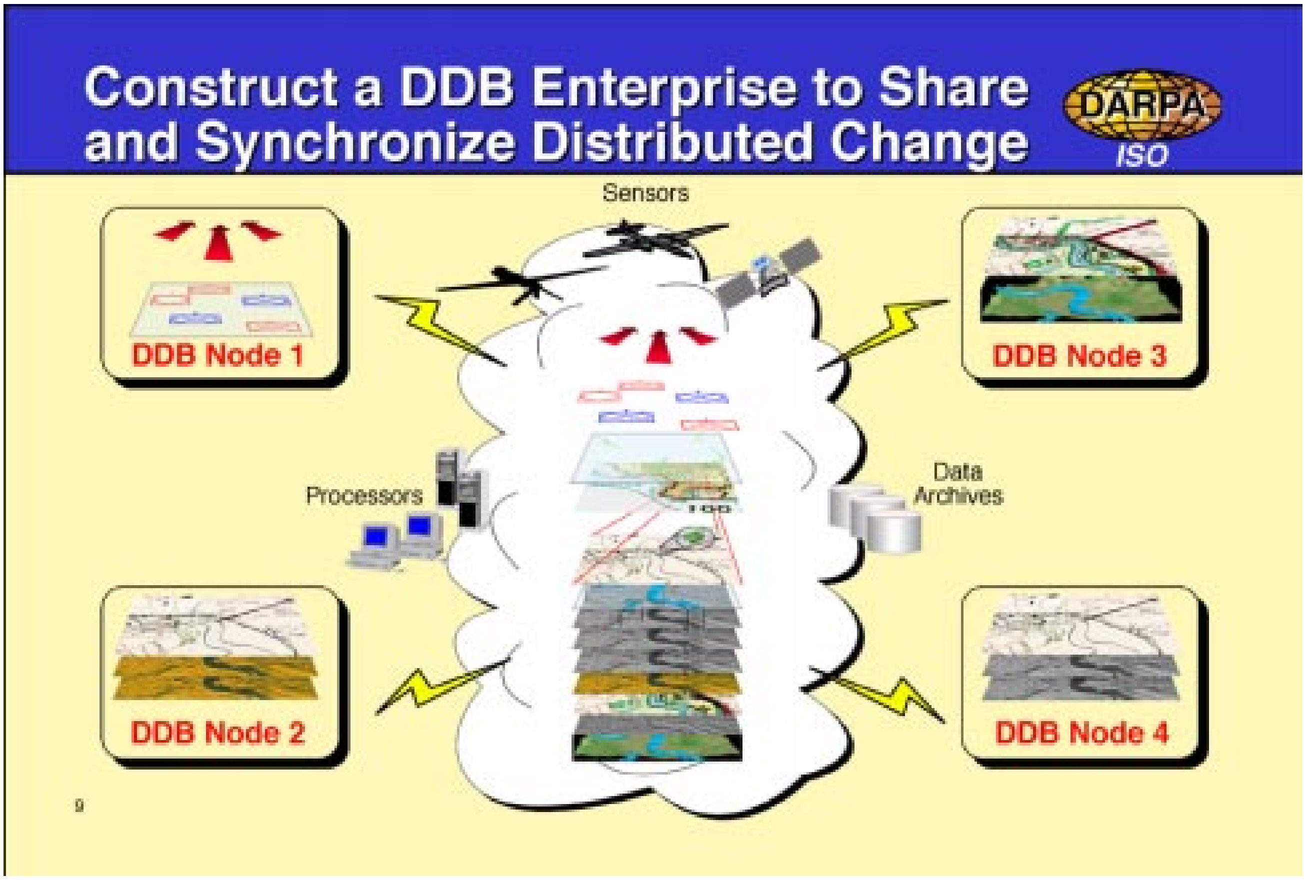
Defining and instantiating "tactically significant change" constitutes a key challenge for DDB developers. Changes occur throughout the battlespace that have little tactical significance, and apparent changes can occur as a result of minor changes in sensor acquisition geometry. Moreover, the significance of a battlespace change varies across operational scenarios, and must often be judged within a broader situation context that describes the relationship and behavior of aggregate entities.

Highly innovative algorithms, tools, and knowledge acquisition techniques are required that allow a user to monitor the sensed battlespace over time, establish a baseline model of normal spatial and temporal conditions and behaviors, capture this knowledge in the Dynamic Situation Model, and continuously adapt the baseline to keep pace with new or modified battlespace conditions.

In this example, a model of normal battlespace conditions and behaviors has been constructed by analyzing the sensor history over an extended time period. A number of possibly significant changes identified in the previous example have been eliminated by comparing them with expected changes predicted by the model. Multisensor information is then fused by analysts and applications to explain the remaining changes. These include the creation of a new military emplacement, an abnormal traffic pattern, several aircraft missing from an airfield apron, and an unexpected destination point for military traffic.

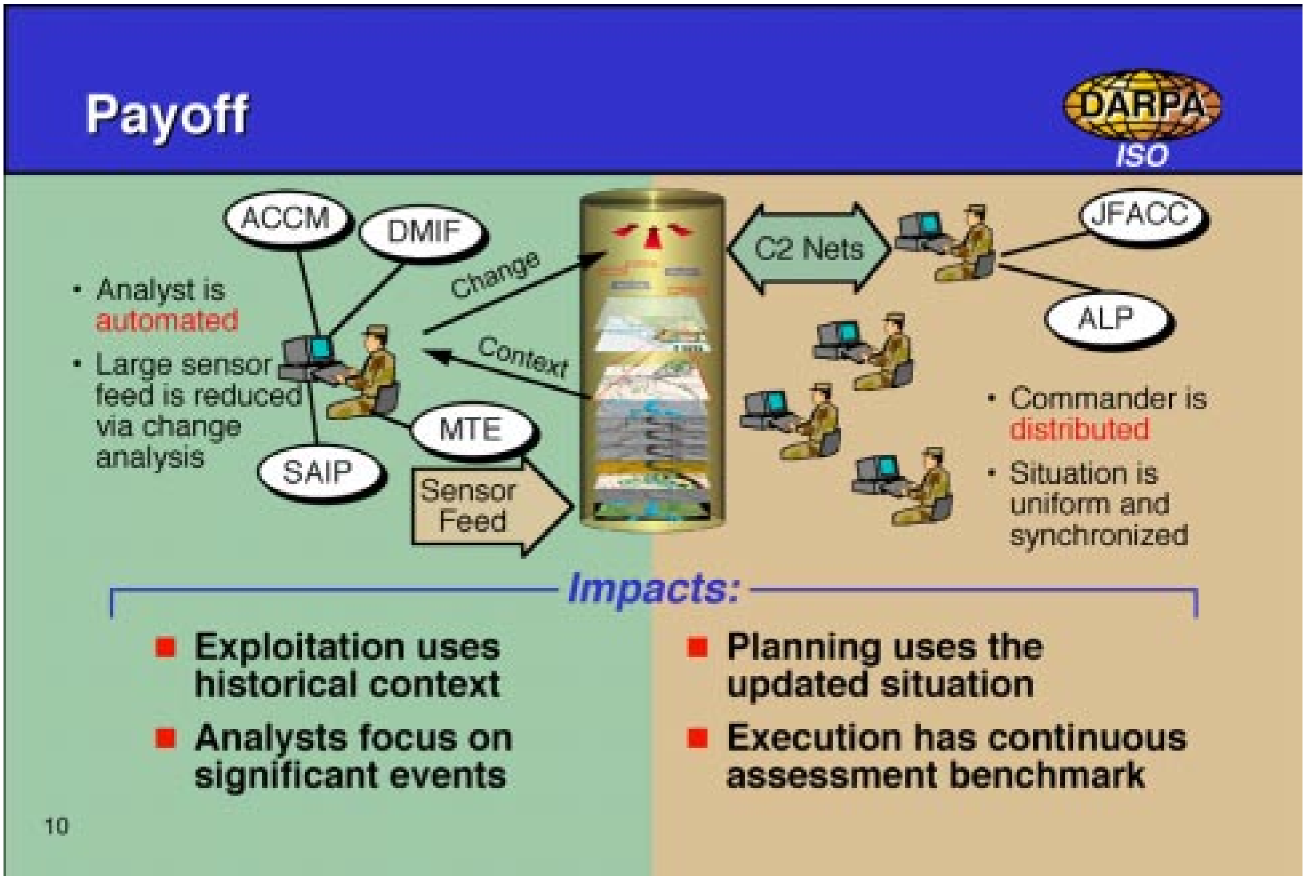
The objective of goal (3) is to provide warfighters the ability to rapidly and efficiently share tactically significant situation information across a large number of distributed DDB nodes. A near-term challenge of this objective is to integrate Dynamic Database and Dynamic Multi-user Information Fusion (DMIF) technologies to provide the warfighter a single system for quickly and efficiently converting massive quantities of raw sensor data into actionable situation intelligence. Formal technology integration activities will begin in mid-FY 1999.

A longer term challenge of this objective is to develop an "active" database that continuously assesses the perishability, value, and uncertainty of the information it contains, and proactively tasks distributed resources to add, replace, or update this information in accordance with changing user information priorities. A resource management architecture must also be developed that provides control strategies for managing distributed collection, processing, and information resources, and upon mechanisms for transacting and synchronizing change across distributed sites. These include transaction languages and protocols that allow new nodes to seamlessly enter and exit the DDB web, monitor database conditions for change, trigger external processes when conditions meet posted criteria, propagate changes and updates across nodes, and support queries and searches of distributed databases.



Dynamic situation estimates will be distributed throughout the battlespace through a "Dynamic Database Web" in which distributed users identify and rapidly share dynamic situation information. The DDB web concept is predicated on the assumption that a global situation estimate cannot be maintained in a central, monolithic repository. Rather, it will be composed of local situation estimates maintained respectively by local command or intelligence centers. Information used to produce local situation estimates may itself be composed from multiple heterogeneous repositories serving specialized data production needs. DDB situation information will be accessed through a single logical interface that makes information sources transparent to the user.

Situation changes are commonly shared today across echelon, service, discipline, and geographic boundaries by radio and telephone. Advanced systems, such as the Global Command and Control System, allow distributed users to share viewable electronic displays of local operational pictures. Both these fail to provide a mechanism to seamlessly integrate changing situation information, and to maintain alternative, competing explanations of local situation events. A key challenge of this goal, therefore, is to develop a flexible information representation of the dynamic battlespace (i.e., a Dynamic Situation Model) that yields a consistent framework for sharing rapidly changing and often uncertain situation information.



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